Real-time Security-Constrained Economic Dispatch and Commitment in the PJM : Experiences and Challenges

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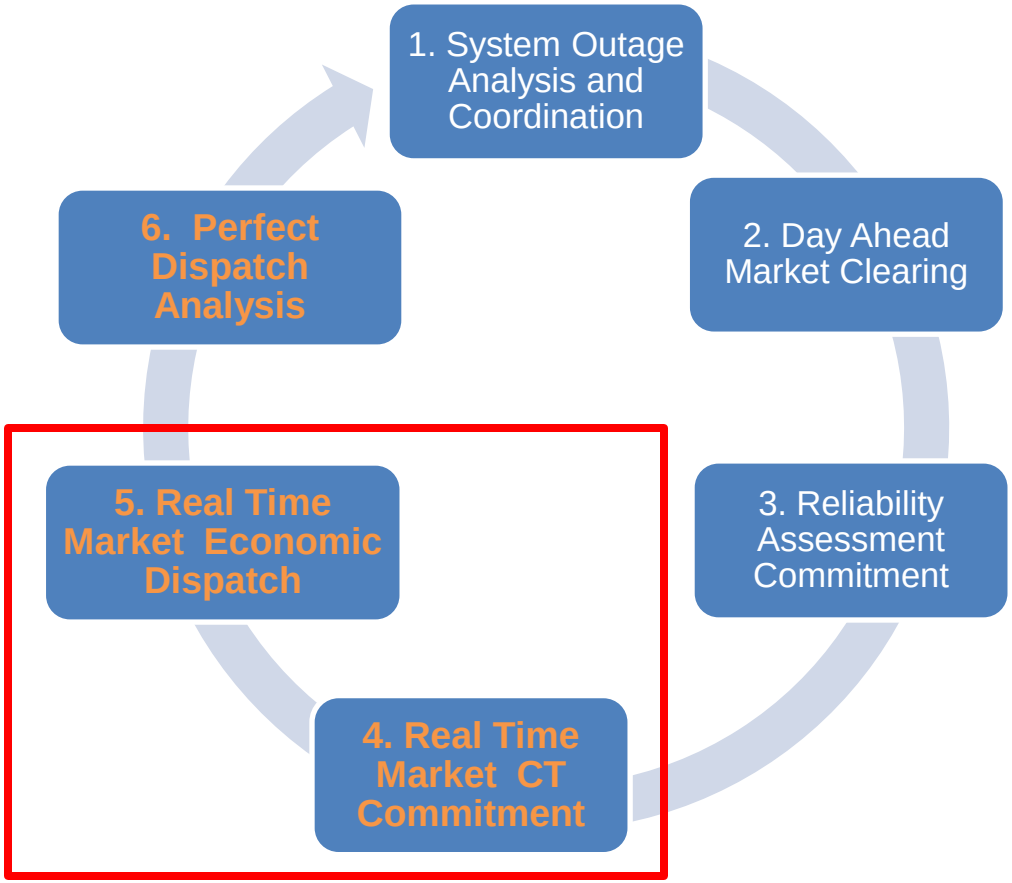
Real Time and Day Ahead Market Cycle



Drivers for dispatch software innovation

- At certain times, resource owners perceive dispatch instructions as ‘unrealistic’. Proactive dispatch signals with higher stability are desired.
- Greater efficiency and lower overall production cost is achievable.
- Advances in operator visualization tools have demonstrated value in continued emphasis on operational trend analysis to increase situational awareness.
- Technology advances provide opportunity to integrate trend analysis into optimization and to accommodate more sophisticated and adaptive resource models

Security Constrained Economic Dispatch Issues

- Previous Economic Dispatch Tools
  - Real-time Unit Dispatch System (RT UDS)
    - Projecting out 15 minutes to dispatch online units
    - No CT commitment, only de-commitment
  - Look-Ahead Unit Dispatch System (LA UDS)
    - Projecting out 15, 30, 45, & 75 minutes to commit CTs
    - No coupling of LA solutions or coupling of RT UDS and LA UDS results
- The lack of continuity between solutions was not in synch with dispatcher's operating plan
- Poor continuity between user interface and work performed by dispatchers

New SCED design

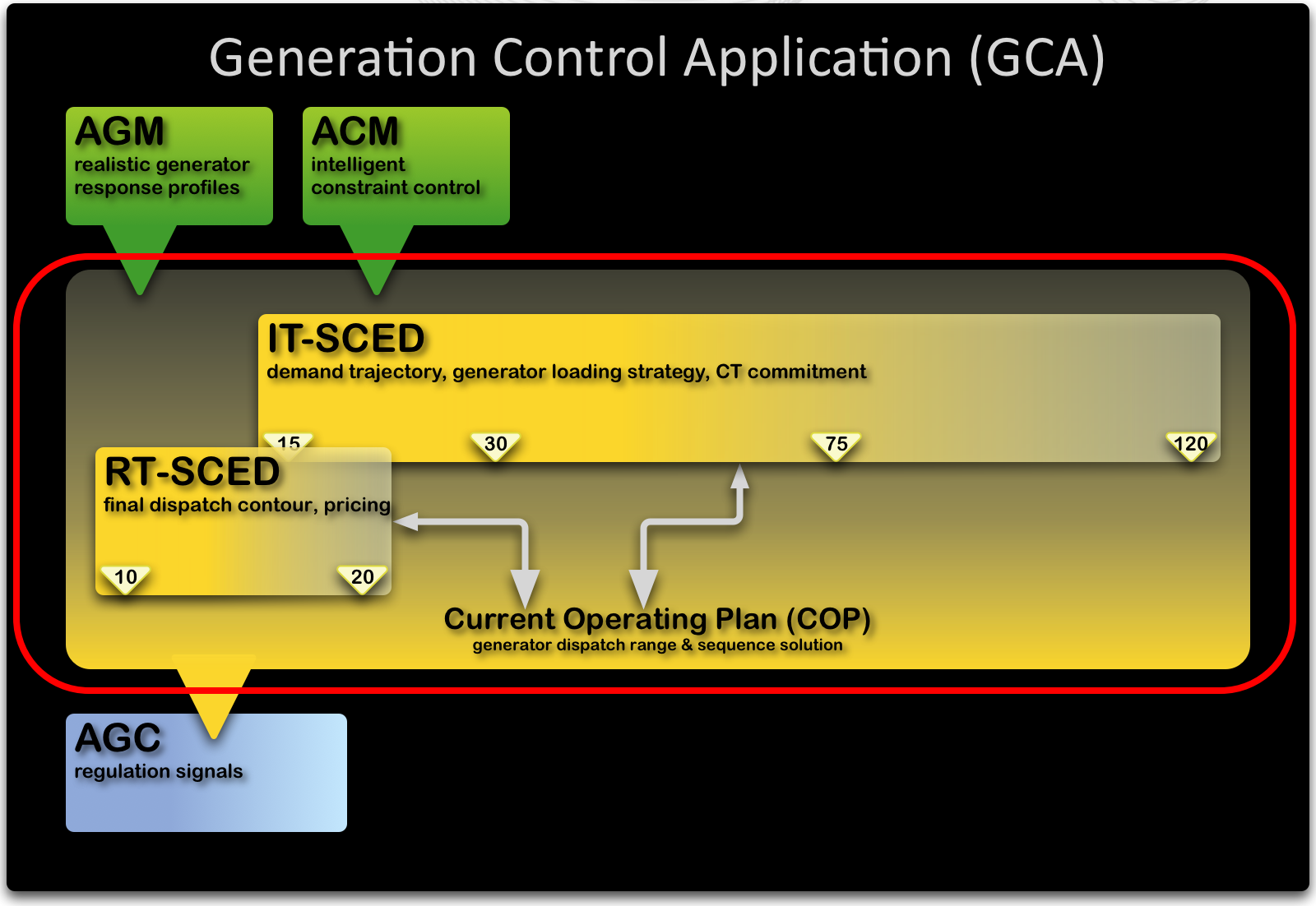
- The objective is to yield a time-coupled resource operating plan
  - Introduce multi interval/multi horizon solution with dynamic contour projection for individual resource dispatch instructions
  - Employ a “time-coupled” optimization engine
  - Realistic generator characteristics and behavior
- Dispatcher-focused user interface
  - Unit dispatch and transmission constraint information are displayed in a more integrated and relevant format
  - Many dispatcher actions can occur directly from the user interface

What is GCA?

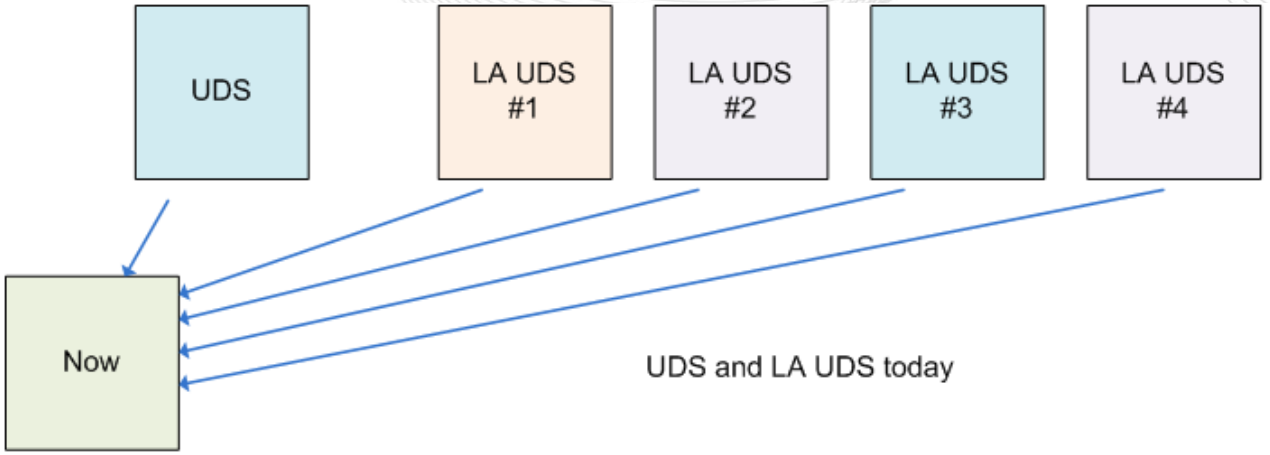
Generation Control Application (GCA) is the PJM solution to real-time CT commitment and real-time economic dispatch. GCA consists of the four high-level functions:

Automatic Generation Control (AGC)
Multi-interval Security Constrained Economic Dispatch (SCED) • Rea-time SCED & Intermediate Term (IT) SCED
Adaptive Constraint Model (ACM) – In evaluation phase
Adaptive Generator Model (AGM) – In evaluation phase

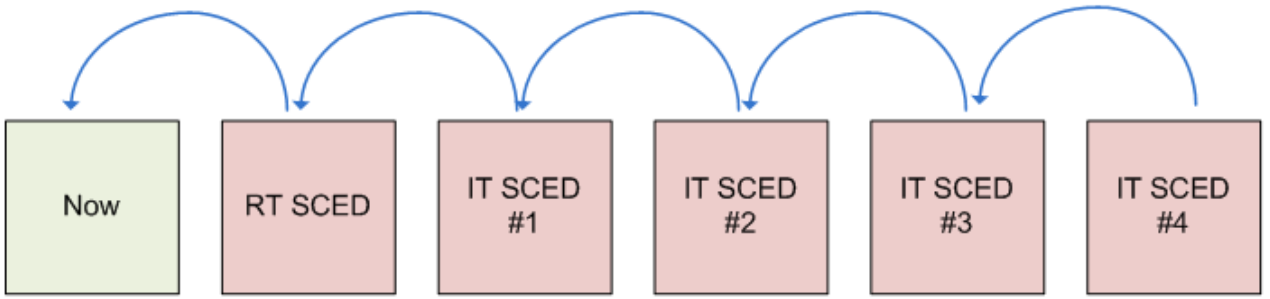
How it all fits together



UDS vs. SCED



UDS and LA UDS today

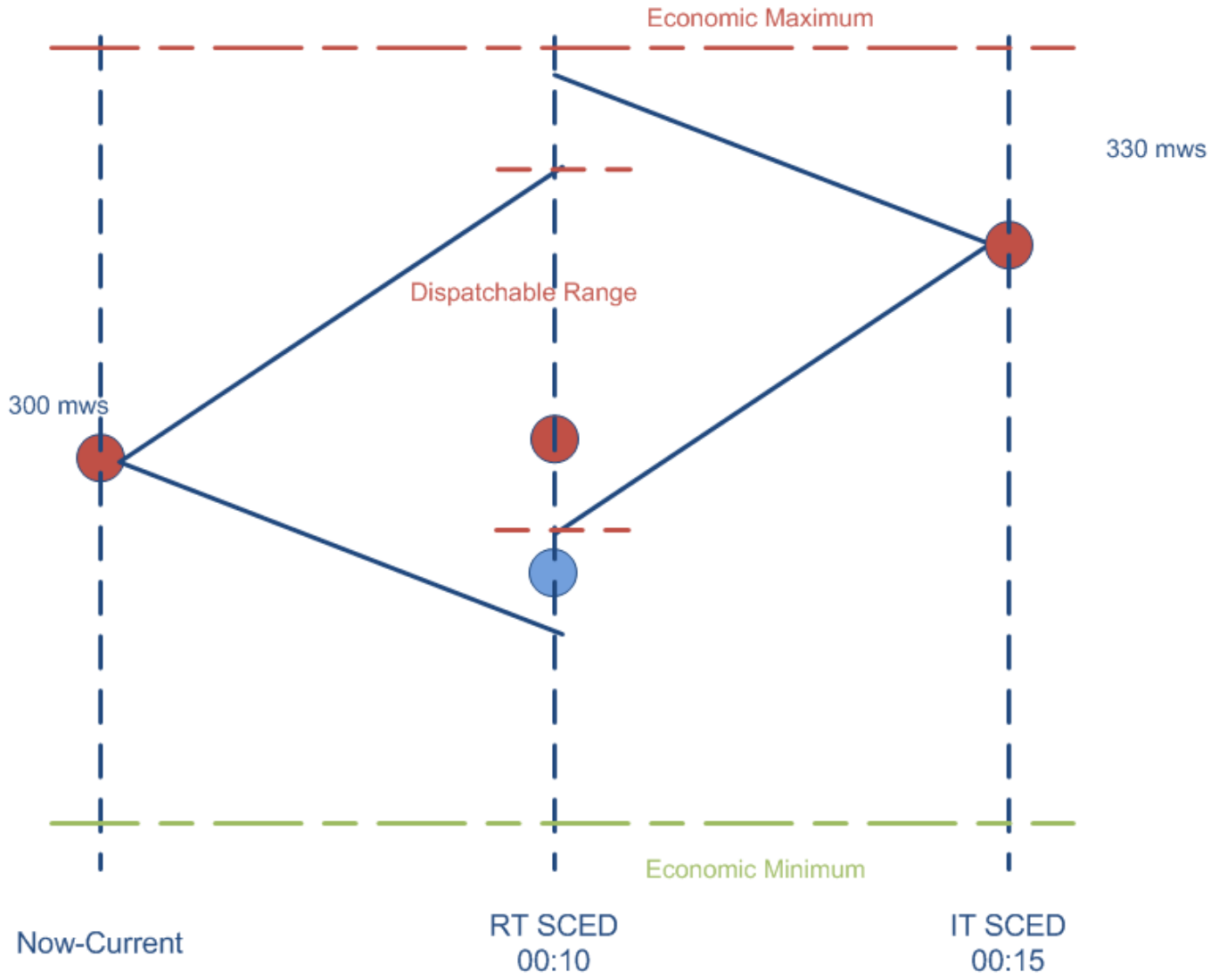


RT & IT SCED

Why are there two SCEDs?

- Processing Speed
- Each has its own objective
- IT SCED
  - CT commitment
  - Guide RT SCED
- RT SCED
  - On-line unit dispatch
  - Pricing Calculation
- 2 Independent engines
  - But IT SCED creates a path for RT SCED to follow
  - This path is referred to as an Envelope

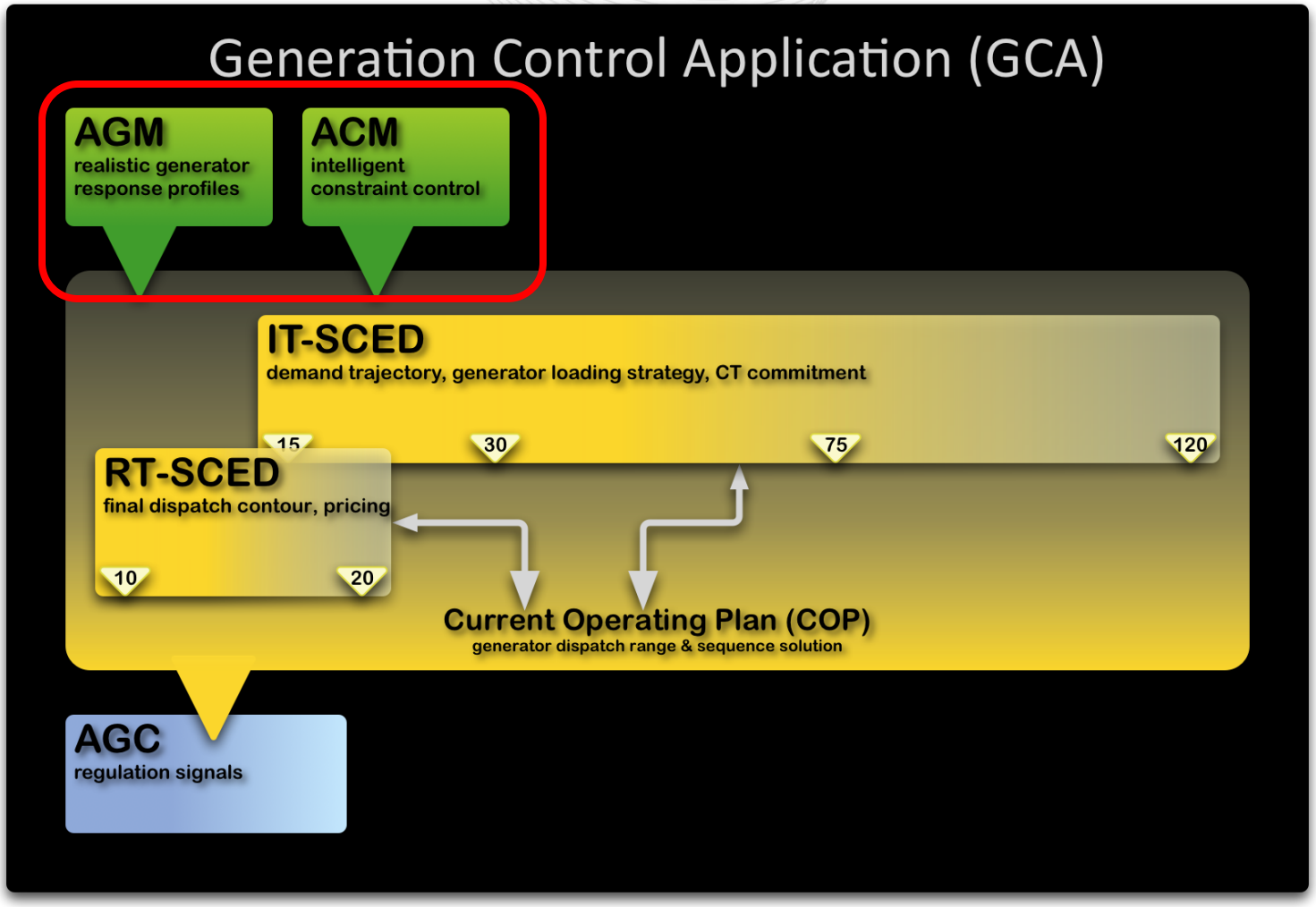
Envelope Concept



Inputs to the SCED Engine

Data	Update rate
Load Forecast	5 minutes
EES Transaction Data	5 minutes
Generator MW output	2 minutes
Transmission Constraints	2 minutes
eMkt – Unit Hourly Updates	1 minute
GPM and AGM	1 minute
Unit bid, schedule, ramp rate, etc.	Available for each case execution from daily input file.
Regulation and Spinning status	Available for each case execution upon becoming effective

How it all fits together



Adaptive Generator Model (AGM)

- Operational history of resource used to predict response to certain dispatch instructions
- Predicted response used in determining dispatch instruction to be issued to resource
- Six parameters are created by AGM
  - Control (Min, Max) MW
  - iRamp Rate(Up,Down)
  - icontrol (Min,Max) MW
- Concept is … probabilistic response model replaces the need to correct bad offer data or explicitly model mill points, dead bands, forbidden zones etc.

Adaptive Constraint Model (ACM)

- Provide analysis to evaluate near-term line loading trends (and PV characteristics) to adapt constraint control strategy based on current conditions
- Group, rank and prioritize active transmission constraints
- Incorporate historical data to assist in anticipating and strategizing constraint control actions
- Concept is to reduce number of “hard” limits that are introduced into the optimization phase

- AGM – pilot of ~20 units
  - This provides better unit-specific capabilities for the internal solution
  - The external control points will still be based on bid-in parameters
  - We will continue to work with members to refine this calculation
  - *Potential* for feedback to the members based on this data – (~1 year from now)
- ACM – working to develop a more proactive analysis of recent constraint history to predict future constraint loading.

SCED User Interface

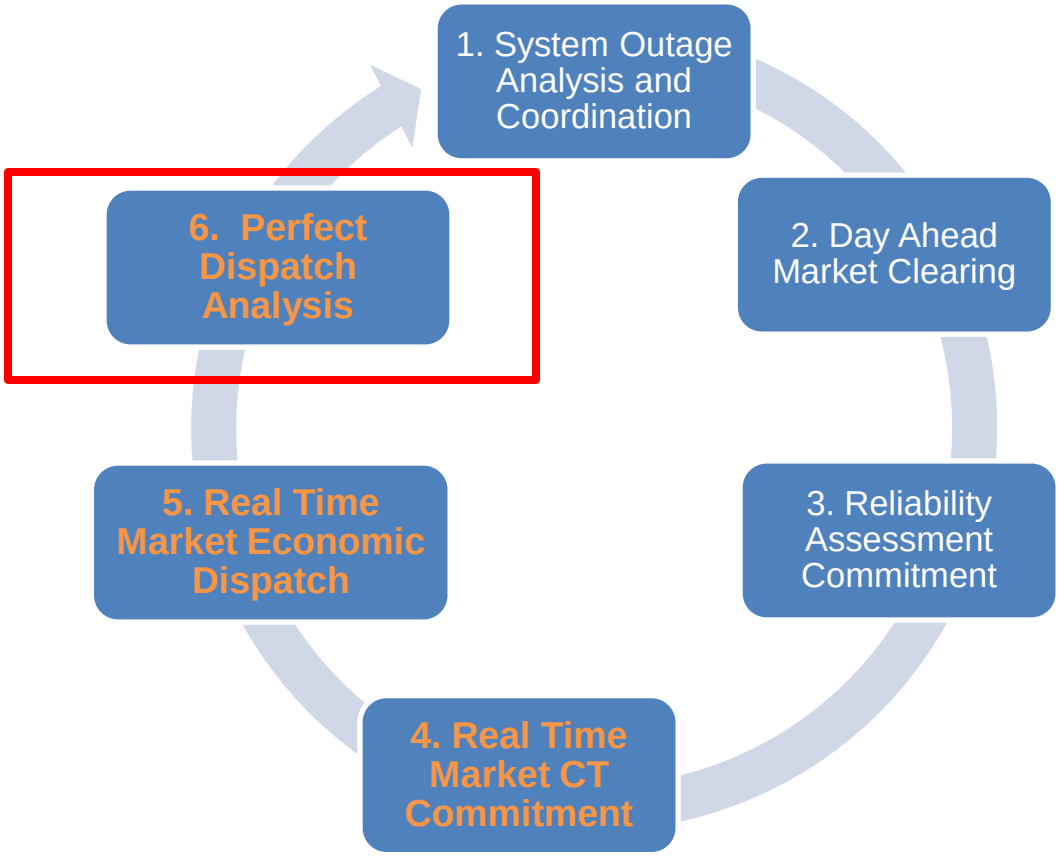
Generation change “donut”

Tangerine (+) : Increase in MW (Raise)
Blue (-) : Decrease in MW (Lower)

Observations

- Adaptive Models enhance performance of dispatch engines
- Real-time Optimization performance must improve to support automation
- Trend visualization well received by dispatchers
- Market response will be enhanced by reduction in dispatch base point volatility and producing dispatch signal trajectories for all resources

Real Time and Day Ahead Market Cycle



Perfect Dispatch Methodology

- "Perfect Dispatch" (PD) calculates the after-the-fact hypothetical least bid production cost (BPC) dispatch using the actual load, interchange, system topology and transmission constraints.
  - PD optimizes the dispatch of the online steam units and all the CT commitments.
- PD objectively evaluates the PJM's performance in dispatching the real-time system by comparing the actual bid production cost with optimized "Perfect" solution.

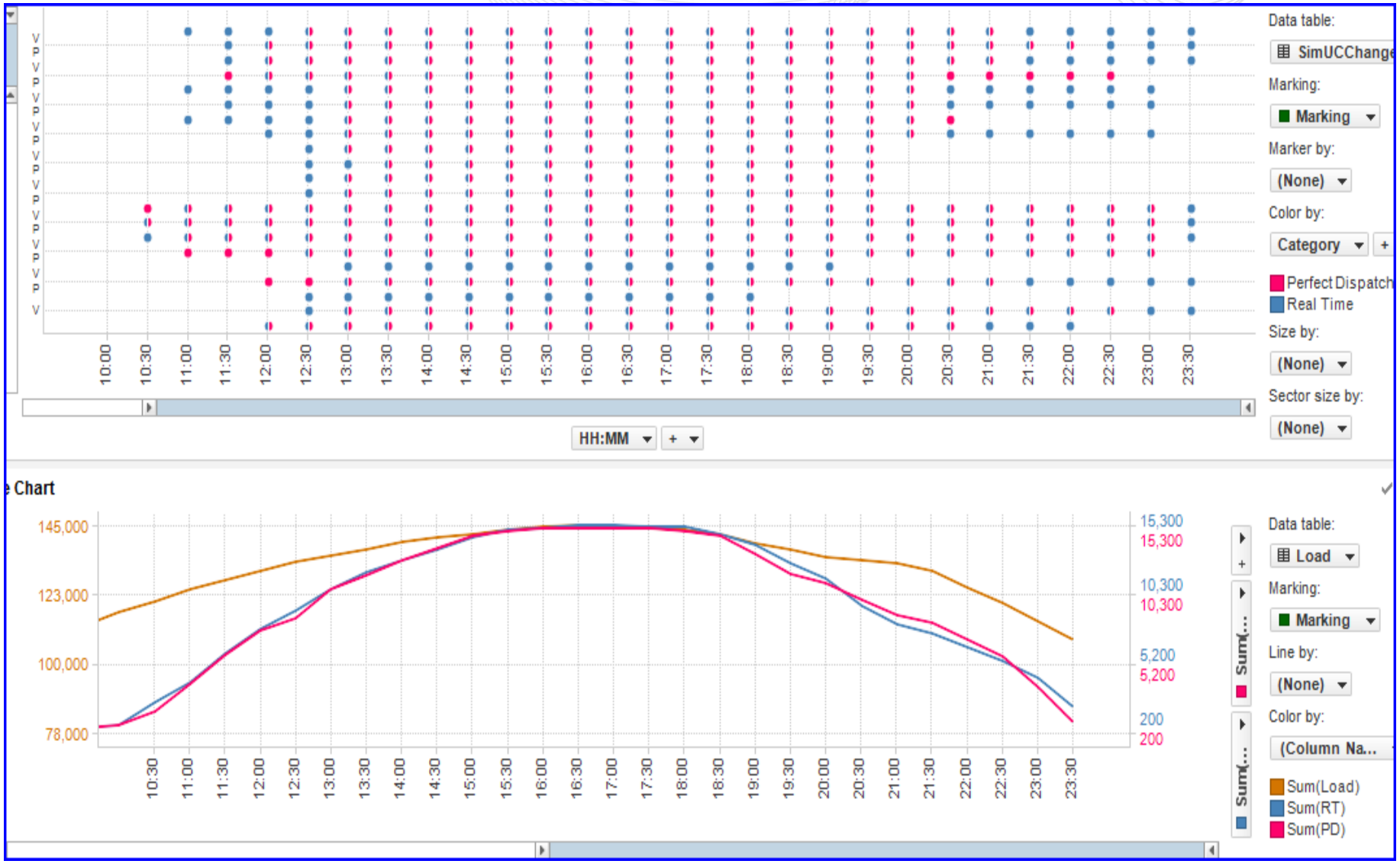
Factors Affecting Perfect Dispatch

- After-the-fact, calculated, Perfect Dispatch solution could never be achieved in actual operations
- The dispatchers must make dispatch decisions based on forecasts of load, interchange, etc. which will never consistently represent actual values
- The dispatchers must also anticipate failure of generators to follow dispatch signals exactly
- The dispatchers must always act with reliability as their primary consideration, requiring them to err on the side of committing slightly more generation rather than less

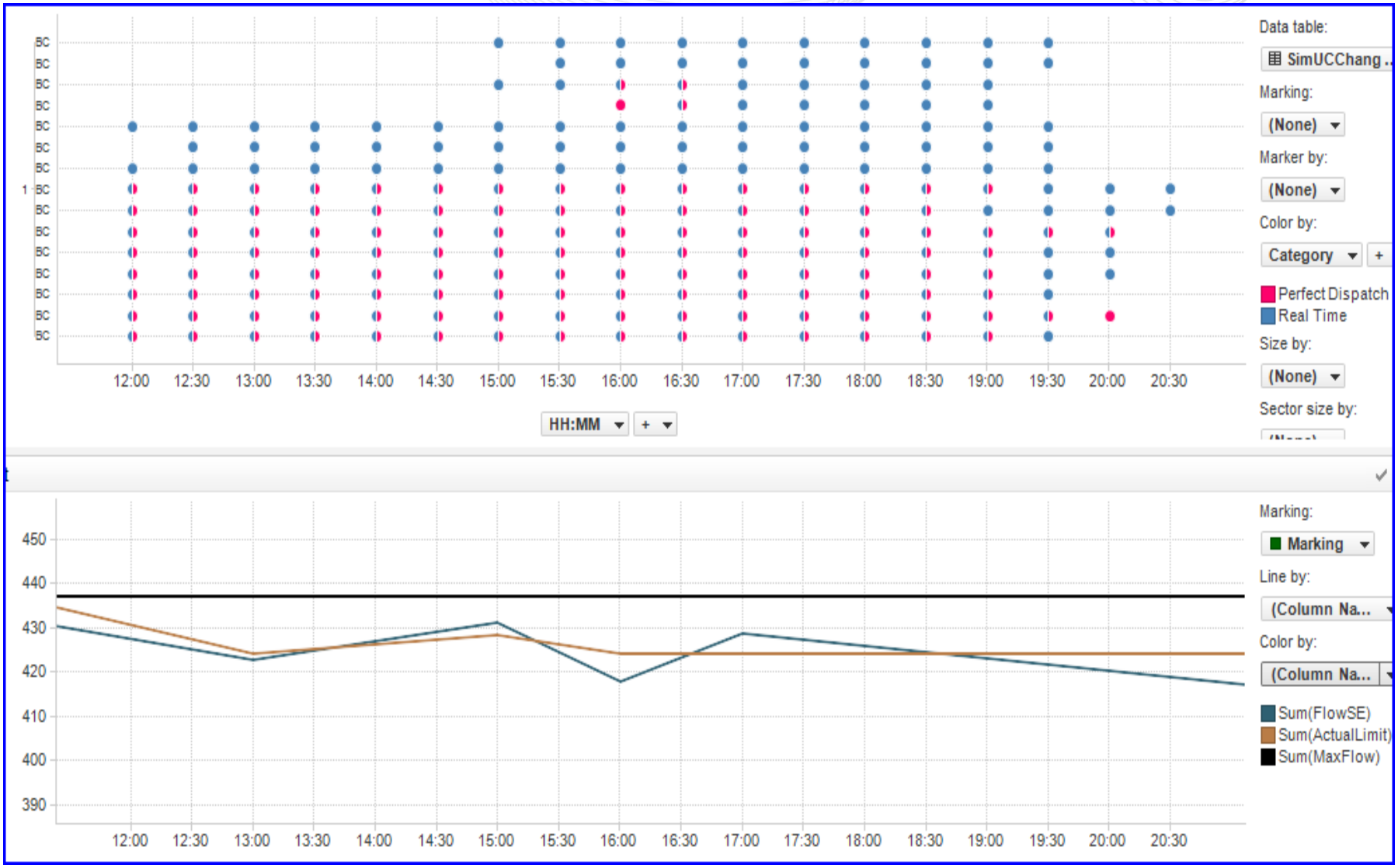
Perfect Dispatch Today

- Perfect Dispatch allows us to:
  - Discover better ways to optimize the dispatch solution
  - Incorporate lessons learned into dispatch actions
  - Synthesize results into actionable plan
  - Leverage operational patterns to reduce uncertainty
- Initial analysis before 11 am each day
- Often, the same plan applies day after day as similar conditions arise
  - Recognizing CT needs and patterns
  - Adjusting to major system outages

Sample output of Perfect Dispatch – Economic CTs

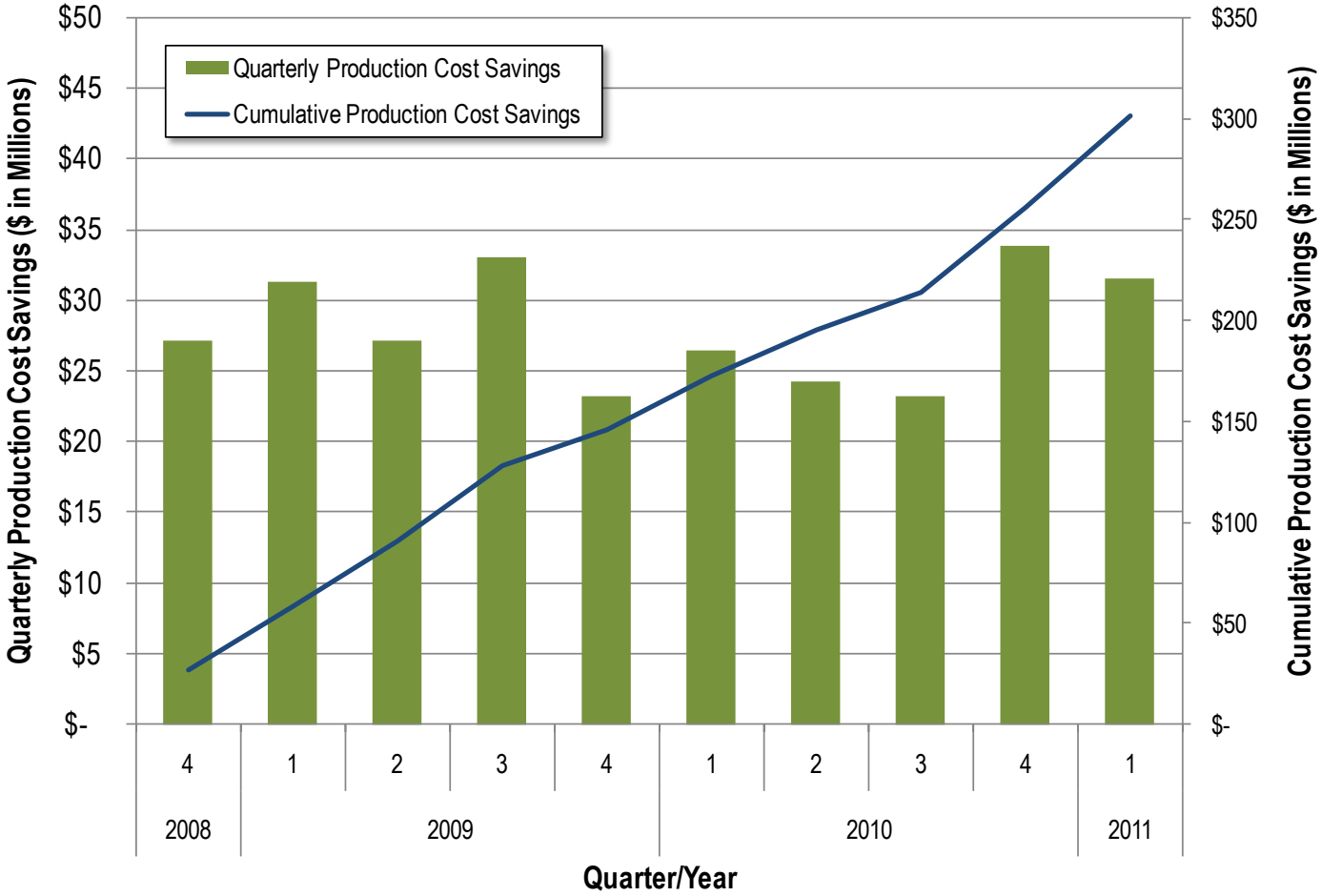


Sample output of Perfect Dispatch – CTs for a constraint ctrl



2011 Perfect Dispatch Performance

Perfect Dispatch Estimated Production Cost Savings[1] Through March 2011



[1] Estimated Production Cost Savings based on 2008 Year-End Performance of 98.36%.

Future Development Opportunities

Future Developments - SCED and UI Advances

- Advances in operator visualization tools have demonstrated value in continued emphasis on operational trend analysis to increase situational awareness.
- Automated input data error detection / correction
- Technology advances should integrate trend analysis into optimization and to accommodate more sophisticated and adaptive resource models

Future - Incorporate Perfect Dispatch in Control Engines

- Concept is…turn after-the-fact analysis results into real-time actions
- Better visualization of the how the PD results incorporate into an action plan to improve the next day operation.
- Incorporate PD results as input into IT and RT SCED engines.

Future Work - Improved Data for Real Time Constraints

- Improved visualization of the approaching constraints and interaction between constraints
  - Seeing potential constraints hours before they occur provides more options for control and smoother control
  - Representation of control options
  - Prioritize dispatch actions based on facility loading trends/projections
  - Reduce dispatch volatility due to sudden changes in constraint loading

Questions